LEASECON 2020
International Conference «Land Economy and Rural Studies Essentials»

ANALYSIS OF INDEPENDENCE OF PORK PRICES IN RUSSIA FROM WORLD PORK PRICES

Igor M. Gogolev (a), Rinat V. Fayzullin (b)*, Ivan I. Chichenkov (c)
*Corresponding author

(a) Izhevsk State Agricultural Academy, 30, Sverdlova St., Izhevsk, Russia, gogolev_im@mail.ru
(b) Izhevsk State Technical University named after M.T. Kalashnikov, 7, Studencheskaya St., Izhevsk, Russia, rf85@ mail.ru
(c) Izhevsk State Technical University named after M.T. Kalashnikov, 7, Studencheskaya St., Izhevsk, Russia chichenkovii@gmail.com

Abstract

The article considers the Russian pork market as a part of the world market. It has been determined that over the past 10 years, the market has undergone many changes due to Russia's accession to the WTO, the introduction of sanctions against the country, the introduction of restrictive measures on pork import from some countries. Determining the market's independence from imports required making up a model of the relationship between pork prices in Russia and world pork prices. The data on weekly average market prices for pork in Russia (State Statistics Service) and the data on prices for pork futures on the Chicago produce exchange (prices are given in rubles) have been analyzed. It has been assumed that if the market is not dependent on imports, prices for pork should not depend on world prices, and vice versa. The analysis carried out using the Granger causality concept has shown that in 2014-2019, pork prices in Russia did not depend on world prices. Granger causality tests the hypothesis on whether one of the variables under consideration can be the cause of another variable. There is a logical explanation for the lack of dependence in the fact that pork imports in Russia occupy a small share and were decreasing over the observed period (data are given both in value terms and in volume terms). The proposed method allows us to assess the independence of local food markets from world prices.

2357-1330 © 2021 Published by European Publisher.

Keywords: Granger causality, pork, pricing

1. Introduction

Pig farming is an important sector of the food market. The share of pork meat in Russia makes about 35% of meat production (2nd place after poultry). The current condition of pig farming should be considered in terms of changes of recent years.
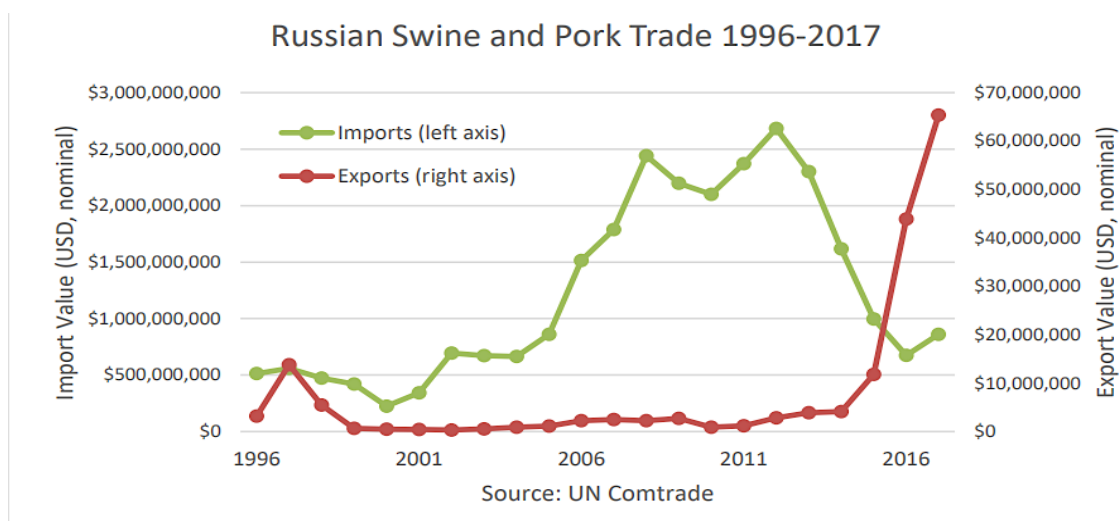

Figure 1. Volumes of pork exports and imports in Russia over the period of 1996-2017 (UN Comtrade, 2021)
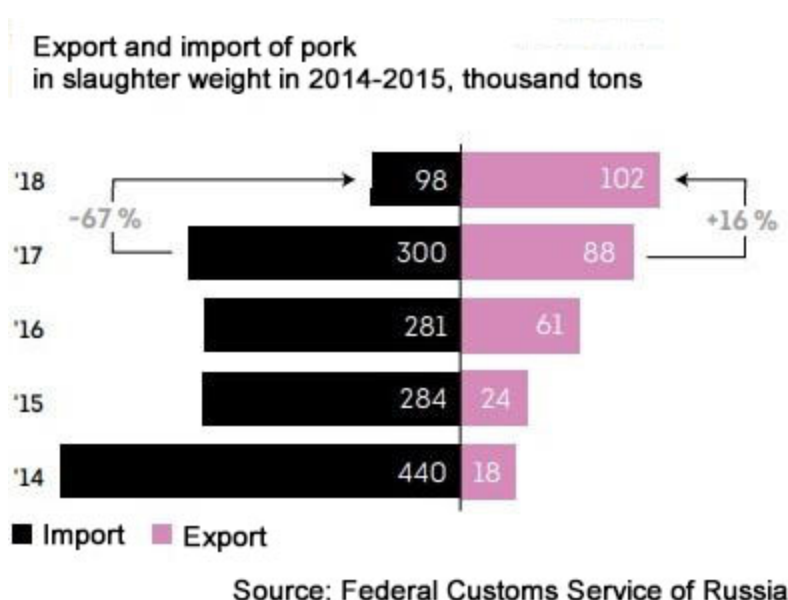
Figure 2. Dynamics of the volume of pork exports and imports in Russia in slaughter weight

Within the framework of one decade (2010-2020 years), several events and facts that have significantly changed the condition of the pork market and the pig industry in Russia can be singled out. On December 16, 2011, Russia joined the WTO, which imposed certain requirements. In 2014, leading Western countries introduced sanctions against Russia, which still continue to have a strong impact on the Russian economy. In turn, Russia imposed sanctions on pork import from the EU in the same year. Some

restrictions seem to be justified. For example, an outbreak of African swine fever was declared as one of the reasons for restrictions. First of all, it affected large importers of live pigs to Russia – Lithuania and Poland (Blanchard & Wu, 2019). Some sanctions should be considered "retaliatory", i.e. introduced in response to sanctions imposed by a number of Western countries on August 7, 2014. Thus, Russia imposed a ban on food imports. These facts affected the Russian pork market, including the volume of exports and imports both in value terms (Figure 01) and in volume terms (Figure 02).

2. Problem Statement

Many research works are devoted to pork pricing (Brown, 2001; Gervais & Larue, 2009), but the dependence of the country's pork price on world pork prices has not been studied.

On the one hand, prices for pork in a country may depend on world prices, especially when the market is dependent on imports. On the other hand, prices for pork depend on internal factors (producer costs) as well. In terms of costs, researchers use different enterprise performance criteria (Düsseldorf 2013; Hewitt et al., 2018; Stalder, 2017).

Felt said that reductions in tariff barriers, domestic support, and export subsidies contribute to the globalization of agricultural markets. As a result, one should expect agricultural markets to be increasingly competitive (Felt et al., 2011). However, the markets of some countries may function in different conditions, such as export or import restrictions. The restrictions may be caused by disease outbreaks or political decisions (Blanchard & Wu, 2019; Blayney et al., 2006; Brown, 2001).

According to some analysts, prices for products in a country should depend on world prices (Dantas & Weydmann, 2009; Selli et al., 2011). Thus, if the market is not dependent on imports, prices for pork should not depend on world prices, and vice versa.

3. Research Questions

To test scientific hypotheses, let us consider the pork market in Russia of 2014-2019 using the following assumptions.

The development of the pork market in the country is influenced by external factors. External factors may include economic (demand, supply, prices) and other factors (sanctions imposed due to various reasons).

If the country's pork market does not depend on imports (or does not depend much), then the country's pork prices do not depend on world pork prices.

4. Purpose of the Study

The present research is aimed at proving the possibility of independence of pork prices in a country from world prices using statistical methods.

5.   Research Methods

Analysis of the dynamics of commodity prices and their mutual influence is used to identify causal relationships (Kolovertnov & Faizullin, 2015). Modern econometric research are characterized by the use of the Granger causality test.

The Granger concept of causality is applied to components of a stationary vector of random processes to test whether one of the variables under consideration can be the cause of another variable. Thus, a variable y_t cannot be considered a cause for a variable x_t if failure to evaluate the impact of past values of the variable y_t does not impair the quality of the value forecast x_t for past values of these two variables.

Let us consider the Granger causality for two variables. The given model has the following form:

$$x_t = \sum_{j=1}^{p} a_j x_{t-j} + \sum_{j=1}^{p} b_j y_{t-j} + v_t$$
$$y_t = \sum_{j=1}^{p} c_j x_{t-j} + \sum_{j=1}^{p} d_j y_{t-j} + w_t$$

(1)

The absence of a causal link from x to y means that $c_j = 0$ when $j = 1, \ldots, p$. The absence of a causal link from y to x means that $b_j = 0$ when $j = 1, \ldots, p$.
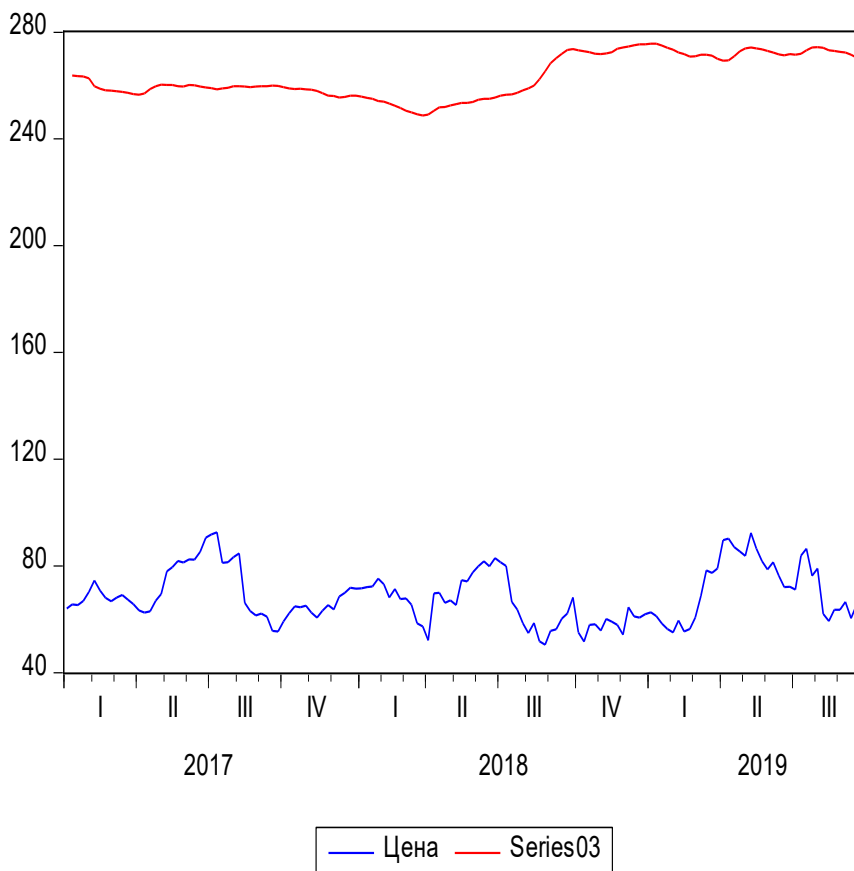

Figure 3. Dynamics of retail pork prices in Russia and the exchange world pork prices

To perform the causality test, a time series must be stationary. The time series is stationary when its expectation value, variance, and autocorrelation are independent of time

The data on weekly average market prices for pork in Russia (State Statistics Service) and the data on prices for pork futures on the Chicago produce exchange (prices are given in rubles) have been analyzed. The price dynamics is shown in Figure 03.

6. Findings

Null Hypothesis: PRICE has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.924296	0.1581
Test critical values:	1% level	-4.023506	
	5% level	-3.441552	
	10% level	-3.145341	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PRICE)
Method: Least Squares
Date: 10/26/19   Time: 10:46
Sample (adjusted): 1/08/2017 9/29/2019
Included observations: 143 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PRICE(-1)	-0.115251	0.039411	-2.924296	0.0040
C	8.229562	2.851833	2.885710	0.0045
@TREND("1/01/2017")	-0.004175	0.009712	-0.429929	0.6679

R-squared	0.058318	Mean dependent var	-0.011049
Adjusted R-squared	0.044865	S.D. dependent var	4.903321
S.E. of regression	4.792065	Akaike info criterion	5.992556
Sum squared resid	3214.944	Schwarz criterion	6.054713
Log likelihood	-425.4677	Hannan-Quinn criter.	6.017813
F-statistic	4.335068	Durbin-Watson stat	1.911916
Prob(F-statistic)	0.014904		

Figure 4. Results of the augmented Dickey-Fuller test for the time series of world pork prices

Null Hypothesis: D(PRICE) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.92348	0.0000
Test critical values:	1% level	-4.023975	
	5% level	-3.441777	
	10% level	-3.145474	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PRICE,2)
Method: Least Squares
Date: 10/26/19   Time: 11:42
Sample (adjusted): 1/15/2017 9/29/2019
Included observations: 142 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PRICE(-1))	-1.012025	0.084877	-11.92348	0.0000
C	0.191937	0.844534	0.227270	0.8205
@TREND("1/01/2017")	-0.002957	0.010141	-0.291573	0.7710
R-squared	0.505639	Mean dependent var		-0.031690
Adjusted R-squared	0.498525	S.D. dependent var		6.993117
S.E. of regression	4.952167	Akaike info criterion		6.058428
Sum squared resid	3408.830	Schwarz criterion		6.120875
Log likelihood	-427.1484	Hannan-Quinn criter.		6.083804
F-statistic	71.08541	Durbin-Watson stat		1.997902
Prob(F-statistic)	0.000000			

Figure 5. Results of the augmented Dickey-Fuller test for the first differences in the time series of world pork prices

Null Hypothesis: RU has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.236188	0.4656
Test critical values:	1% level	-4.025426	
	5% level	-3.442474	
	10% level	-3.145882	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RU)
Method: Least Squares
Date: 10/26/19   Time: 10:51
Sample (adjusted): 1/29/2017 9/22/2019
Included observations: 139 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RU(-1)	-0.017841	0.007979	-2.236188	0.0270
D(RU(-1))	0.882382	0.083765	10.53397	0.0000
D(RU(-2))	-0.175076	0.084700	-2.067027	0.0407
C	4.480882	2.017756	2.220725	0.0280
@TREND("1/01/2017")	0.003094	0.001615	1.916261	0.0575
R-squared	0.597474	Mean dependent var		0.050504
Adjusted R-squared	0.585458	S.D. dependent var		0.818126
S.E. of regression	0.526749	Akaike info criterion		1.591125
Sum squared resid	37.18031	Schwarz criterion		1.696682
Log likelihood	-105.5832	Hannan-Quinn criter.		1.634020
F-statistic	49.72442	Durbin-Watson stat		1.971950
Prob(F-statistic)	0.000000			

Figure 6. Results of the augmented Dickey-Fuller test for the time series of pork prices in Russia

Null Hypothesis: D(RU) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.913724	0.0005
Test critical values:	1% level	-4.025426	
	5% level	-3.442474	
	10% level	-3.145882	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RU,2)
Method: Least Squares
Date: 10/26/19   Time: 11:42
Sample (adjusted): 1/29/2017 9/22/2019
Included observations: 139 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RU(-1))	-0.298349	0.060717	-4.913724	0.0000
D(RU(-1),2)	0.202212	0.085059	2.377314	0.0188
C	-0.026382	0.094586	-0.278926	0.7807
@TREND("1/01/2017")	0.000509	0.001144	0.445104	0.6570
R-squared	0.154311	Mean dependent var		-0.007266
Adjusted R-squared	0.135518	S.D. dependent var		0.574867
S.E. of regression	0.534497	Akaike info criterion		1.613375
Sum squared resid	38.56779	Schwarz criterion		1.697820
Log likelihood	-108.1295	Hannan-Quinn criter.		1.647691
F-statistic	8.211044	Durbin-Watson stat		1.977715
Prob(F-statistic)	0.000046			

Figure 7. Results of the augmented Dickey-Fuller test for the first differences of the time series of pork prices in Russia.

The stationarity of the time series has been determined using the Eviews program (augmented Dickey-Fuller test). The results of the augmented Dickey-Fuller test (ADF) for data on pork prices in the world market are shown in Figures 4 and 5. In general, the results suggest that the series is unstationary. We cannot reject the null hypothesis about the presence of a single root (the probability of its validity is 15.81%).

The figure shows that the world price (PRICE) depends on its previous value (PRICE (-1)), so there is an autocorrelation, which should be checked in the future.

To bring the time series to a stationary form, the standard procedure for moving to the analysis of the first differences in the time series is usually used. In our case, the economic meaning of numbers of the first series of differences shows price changes in relation to the previous period in absolute terms, i.e.

D(PRICE(t))= PRICE(t)- PRICE(t-1). The results are shown in Figures 6 and 7.

The test of the first differences in the time series of world prices for pork proves that the series is stationary.

The same procedure has been used for the analysis of pork prices in Russia. Figures 06 and 07 show the results of the augmented Dickey-Fuller test for the time series of pork prices in Russia and for the first differences in this series, correspondingly.

Taking into account the above information about the presence of autocorrelation in time series, we consider autocorrelation diagrams for the initial time series and the series formed by the first differences. For the correlation study of time series of pork prices see Figure 08 and 09.
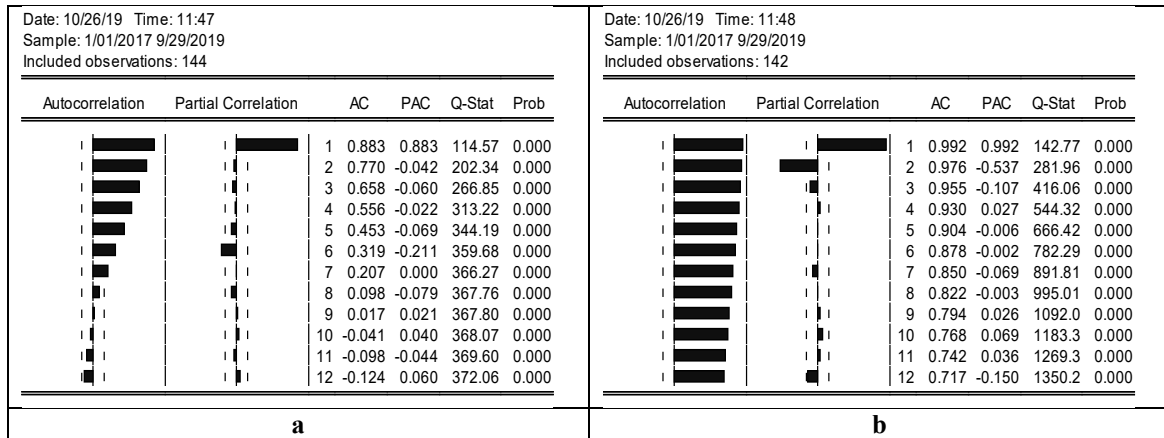
```
Date: 10/26/19  Time: 11:47                          Date: 10/26/19  Time: 11:48
Sample: 1/01/2017 9/29/2019                          Sample: 1/01/2017 9/29/2019
Included observations: 144                           Included observations: 142

Autocorrelation  Partial Correlation  AC    PAC    Q-Stat  Prob    Autocorrelation  Partial Correlation  AC    PAC    Q-Stat  Prob

                               1  0.883  0.883  114.57  0.000                            1  0.992  0.992  142.77  0.000
                               2  0.770 -0.042  202.34  0.000                            2  0.976 -0.537  281.96  0.000
                               3  0.658 -0.060  266.85  0.000                            3  0.955 -0.107  416.06  0.000
                               4  0.556 -0.022  313.22  0.000                            4  0.930  0.027  544.32  0.000
                               5  0.453 -0.069  344.19  0.000                            5  0.904 -0.006  666.42  0.000
                               6  0.319 -0.211  359.68  0.000                            6  0.878 -0.002  782.29  0.000
                               7  0.207  0.000  366.27  0.000                            7  0.850 -0.069  891.81  0.000
                               8  0.098 -0.079  367.76  0.000                            8  0.822 -0.003  995.01  0.000
                               9  0.017  0.021  367.80  0.000                            9  0.794  0.026  1092.0  0.000
                              10 -0.041  0.040  368.07  0.000                           10  0.768  0.069  1183.3  0.000
                              11 -0.098 -0.044  369.60  0.000                           11  0.742  0.036  1269.3  0.000
                              12 -0.124  0.060  372.06  0.000                           12  0.717 -0.150  1350.2  0.000

                     a                                                          b
```

Figure 8. Autocorrelation diagram and private autocorrelation diagram for the pork prices on world market (a) and Russian market (b)

```
Date: 10/26/19  Time: 11:48                          Date: 10/26/19  Time: 11:48
Sample: 1/01/2017 9/29/2019                          Sample: 1/01/2017 9/29/2019
Included observations: 143                           Included observations: 141

Autocorrelation  Partial Correlation  AC    PAC    Q-Stat  Prob    Autocorrelation  Partial Correlation  AC    PAC    Q-Stat  Prob

                               1 -0.011 -0.011  0.0192  0.890                            1  0.746  0.746  80.089  0.000
                               2 -0.013 -0.013  0.0425  0.979                            2  0.470 -0.194  112.13  0.000
                               3 -0.030 -0.030  0.1731  0.982                            3  0.273 -0.002  123.02  0.000
                               4  0.003  0.003  0.1748  0.996                            4  0.140 -0.025  125.92  0.000
                               5  0.139  0.139  3.0810  0.688                            5  0.050 -0.027  126.29  0.000
                               6 -0.110 -0.109  4.9020  0.556                            6  0.014  0.033  126.32  0.000
                               7 -0.009 -0.007  4.9146  0.670                            7  0.024  0.045  126.41  0.000
                               8 -0.090 -0.086  6.1551  0.630                            8 -0.002 -0.091  126.41  0.000
                               9 -0.105 -0.117  7.8744  0.547                            9 -0.037 -0.022  126.62  0.000
                              10  0.015 -0.007  7.9113  0.637                           10 -0.069 -0.033  127.35  0.000
                              11 -0.141 -0.126  11.045  0.439                           11  0.009  0.215  127.36  0.000
                              12 -0.006 -0.025  11.051  0.525                           12  0.120  0.094  129.60  0.000

                     a                                                          b
```
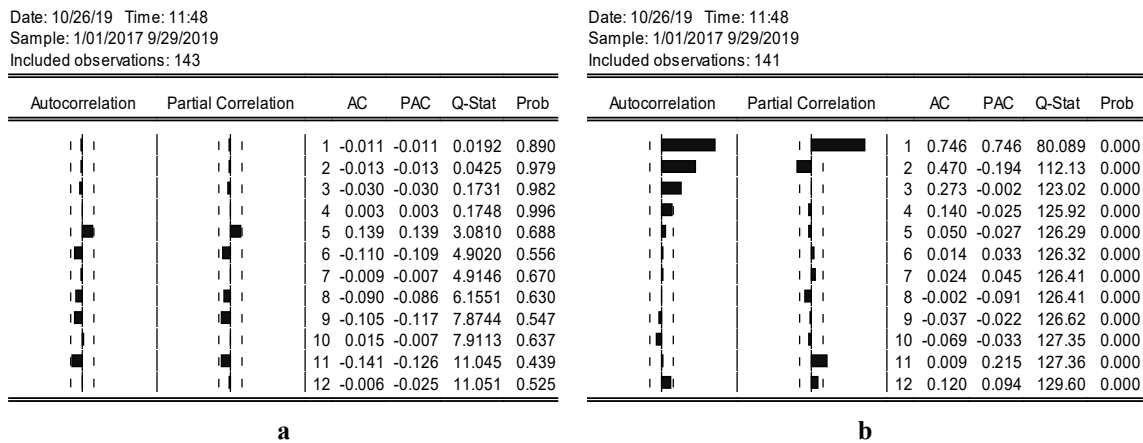
Figure 9. Autocorrelation diagram and private autocorrelation diagram for the first differences of pork prices on world market (a) and Russian market (b)

Analysis of the autocorrelation diagram and private autocorrelation diagram related to the first studied time series – the series of dynamics of the world exchange price for pork, shows that the series is stationary in the first differences, which is confirmed by the lack of grounds for assuming that the expectation value, variance, and single-order coefficient of autocorrelation of the studied process depend on time. As for the second series – the series of dynamics of pork prices in Russia, the analysis of the autocorrelation diagram and private autocorrelation diagram, at a given level of significance, indicates the significance of some coefficients. Therefore, we cannot reject the hypothesis of first-order autocorrelation. Small-scale exceedance is peculiar only of a given significance level, taking into account the already conducted ADF tests. Both series should be considered as stationary in the first differences, i.e. I (1).

Date: 10/26/19   Time: 11:43
Sample: 1/01/2017 9/29/2019
Included observations: 137
Series: PRICE RU
Lags interval: 1 to 4

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	0	0	0	0	0
Max-Eig	0	0	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-503.3767	-503.3767	-502.9916	-502.9916	-502.8819
1	-498.9154	-498.6091	-498.2320	-498.2193	-498.1112
2	-498.5956	-497.2829	-497.2829	-496.9576	-496.9576
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	7.582142	7.582142	7.605716	7.605716	7.633313
1	7.575408*	7.585534	7.594628	7.609041	7.622061
2	7.629133	7.639166	7.639166	7.663614	7.663614
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	7.923162*	7.923162*	7.989363	7.989363	8.059587
1	8.001682	8.033122	8.063530	8.099257	8.133590
2	8.140663	8.193323	8.193323	8.260399	8.260399

Figure 10. Results of the test for co-integration of the series of world pork prices and pork prices in Russia

Having revealed the stationary nature of the studied series in the first differences, we have performed the co-integration test (Figure 10). The Johansen test (Søren, 1991) performed using the Eviews statistical programming package has shown the absence of co-integration. It is known that if x_t, $y_t \sim I(1)$ and they are co-integrated, then the Granger causality must be observed in at least one direction. And on the contrary, if the series are not co-integrated, they most likely do not have causal relationships. Let us also perform the Granger causality test for these series. The results in Figure 11.

Pairwise Granger Causality Tests
Date: 10/26/19   Time: 11:53
Sample: 1/01/2017 9/29/2019
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
RU does not Granger Cause PRICE	141	0.01660	0.8977
PRICE does not Granger Cause RU		1.19604	0.2760

Figure 11. Results of the Granger causality test for the series of world pork prices and pork prices in Russia

It turns out that world pork prices neither affect nor depend on pork prices in Russia. The same conclusions can be drawn from the analysis of the cross-correlation diagram. The diagram is shown in Figure 12.

```
Date: 10/26/19  Time: 11:44
Sample: 1/01/2017 9/29/2019
Included observations: 142
Correlations are asymptotically consistent approximations

        PRICE,RU(-i)        PRICE,RU(+i)      i      lag      lead

            ▪                   ▪              0   -0.0823  -0.0823
            ▪                   ▪              1   -0.0759  -0.0891
            ▪                   ▪              2   -0.0721  -0.0960
            ▪                   ▪              3   -0.0696  -0.1034
            ▪                   ▪              4   -0.0647  -0.1087
            ▪                   ▪              5   -0.0591  -0.1104
            ▪                   ▪              6   -0.0506  -0.1052
            ▪                   ▪              7   -0.0348  -0.0968
            |                   ▪              8   -0.0154  -0.0940
            |                   ▪              9    0.0039  -0.0870
            |                   ▪             10    0.0209  -0.0802
            ▪                   ▪             11    0.0381  -0.0704
            ▪                   ▪             12    0.0562  -0.0562
```

Figure 12. Diagram of cross-correlation between the series of world pork prices and pork prices in Russia

The analysis has shown that pork prices in Russia are resistant to changes in world pork prices. This fact does not prove that changes in the world market do not completely affect the Russian market. However, changes in world prices during the analyzed period did not have a statistically significant impact on retail prices for pork in Russia.

This fact is explained by the fact that the share of imported pork on the Russian market is small and is not able to have any significant direct impact on retail pork prices in Russia.

7. Conclusion

Thus, it has been proved that Russia's pork market does not depend on imports, i.e. the country's pork prices do not depend on world pork prices. The analysis carried out using the Granger causality concept has shown that in 2014-2019, pork prices in Russia did not depend on world prices. The absence of dependence also coincides with the identified trends observed in the analyzed period. Imports decreased (both in value terms and in volume terms). The proposed method allows us to assess the independence of local food markets from world prices.

References

Blanchard, E., & Wu, M. (2019). Externalities and Agricultural Import Bans: Evaluating Regionalization Measures in Light of the Russia–Pigs Dispute. *World Trade Review*, *18*(2), 173-195.

Blayney, D. P., Dyck J. H., & Harvey, D. J. (2006). *Economic effects of animal diseases linked to trade dependency*, 23-29. https://doi.org/1490-2016-127902

Brown, J. (2001). Price discrimination and pricing to market behaviour of Canadian canola exporters. *American Journal of Agricultural Economics*, *83*, 1343-1349.

Dantas, F., & Weydmann, C. L. (2009). Chicken meat: an analysis of the relationship between producer prices and export.

Düsseldorf, S. (2013). Concept of key performance indicators controlling consumer oriented quality and herd health management in a Bavarian pork chain. Dissertation. Rheinische Friedrich-WilhelmsUniversität, Bonn.

Felt, M. H., Gervais, J. P., & Larue, B. (2011). Market power and import bans: the case of Japanese pork imports. *Agribusiness*, *27*(1), 47-61.

Gervais, J-P., & Larue, B. (2009). A joint test of price discrimination, menu costs and currency invoicing. *Agricultural Economics*, *40*, 29-41.

Hewitt, S., Green, M., & Hudson, C. (2018). Evaluation of key performance indicators to monitor performance in beef herds. *Livestock, 23*(2), 72-78.

Kolovertnov, R. A., & Faizullin, R. V. (2015). Methodology for forecasting prices for non-ferrous metal in the Russian Federation based on the dependence on world metal prices. *Economics and management of management systems*, *18*(4.1), 166-173.

Selli, F., Bayaner, A., Akdi, Y., & Sahin, A. (2011). Dynamic Relationships in Meat Market. *Electronic Journal of Applied Statistical Analysis*, *4*(1), 83-90.

Søren, J. (1991). Estimation and Hypothesis Testing of Co-integration Vectors in Gaussian Vector Autoregressive Models. *Econometrica, 59*(6), 1551-1580.

Stalder, K. J. (2017). *Pork industry productivity analysis.* http://www.pork.org/wp-content/uploads/2010/04/pork-industry-productivity-analysis-2015-summary.pdf

UN Comtrade (2021). *"UN Comtrade" refers to the United Nations Commodity Trade Statistic Database*. Retrieved on 29 March 2021 from: https://comtrade.un.org